SCIENCE

A WEEKLY JOURNAL DEVOTED TO THE ADVANCEMENT OF SCIENCE, PUBLISHING THE OFFICIAL NOTICES AND PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

FRIDAY, OCTOBER 28, 1904.

CONTENTS:

MSS. intended for publication and books, etc., intended for review should be sent to the Editor of SCIENCE, Garrison-on-Hudson, N. Y.

*PRESENT PROBLEMS OF GEOPHYSICS.**

ADVANCES in science are seldom made without a view to the solution of specific, concrete problems, even when the results of investigation possess the widest generality. The history of science is full of instances of the fruitfulness of researches the immediate purposes of which were narrowly defined. Geophysics is only that portion of general physics, including under that term physical chemistry, which is applicable to the elucidation of the past history and present condition of the earth. It is thus a very definite branch of applied science, the exigencies of which call for the solution of a group of related problems. These, however, possess great interest apart from their application to the globe, while for the most part they offer very serious experimental and theoretical difficulties. Had they been easy, they might have been solved long ago, for many of these problems have been propounded and more or less discussed from the birth of modern science to the present day. Their difficulty, not lack of recognition of their importance, has postponed their solution.

The main purpose of this paper is to deal with the order in which it would be expedient to investigate the questions embraced under the head of geophysics, but a brief and incomplete enumeration of the problems from a geological standpoint will serve to lend a coherency and a human

* Address delivered at the International Congress of Arts and Science, at St. Louis, before the Geophysical Section of Department 12, on September 21, 1904.

interest to the subject which it would otherwise lack.

Physical geology begins with the solar nebula and the genesis of the earth-moon system. The harmonies of the solar system compelled the immortal Kant and the ever-living Laplace to seek the origin of the planets, the sun and the other stars in heterogeneous nebulas which they supposed to have condensed about one or several nuclei. Every attempt to devise an essentially different hypothesis has failed, and every history of the globe which begins after the birth of the planet is unsatisfying. In the drama of the universe there must have been pre-nebular scenes, but of these we have as yet no inkling. The nebular hypothesis, as its authors propounded it, explains the similarity in the composition of the members of the solar system which is indicated by the analysis of meteorites and by the spectroscope, though the facts thus revealed were unknown to Kant and Laplace. It is also compatible with and accounts for the heterogeneity in the composition of the earth manifested in the actual asymmetric distribution of oceans, mountain ranges and anomalies of gravitational force, as well as in the curiously local occurrence of certain ores (such as those of tin and mercury) and in the predominance of certain alkalies among the rocks over wide areas.

This heterogeneity, however, is of a small order of magnitude. The general dependence of gravity on latitude, the nearly spheroidal shape of the earth and other phenomena show that the distribution of density is nearly symmetrical, while the divergence of the spheroid from the figure characteristic of a fluid of the same mean density and mass as the earth demonstrates that the interior layers of equal density are oblate. These and similar facts are consistent with and are strong evidence for the hypothesis that the globe has been fused at least to a considerable depth from the growing surface of the gathering nebulous mass. Nevertheless, Houghton, and more recently Professor Chamberlin, have supposed that the accretion of nebulous matter was so slow that the heat of impact did not suffice to produce fusion. The hypothesis of superficial fusion is not incompatible with the minor heterogeneity pointed out above; for the laws of diffusion in viscous fluids give proof that sensibly perfect homogeneity could not be produced even in 50,000,000 years throughout a body of liquid originally heterogeneous and possessing a tenth of the mass of the earth. On the other hand, there is no known ground other than mere convenience for supposing an original homogeneity either of the nebula or of the earth.

The problem of the distribution of density in the earth is one of the most important in all geophysics. It is as significant for geodesy and terrestrial magnetism as for geology. That Laplace's empirical law represents it approximately is generally acknowledged, but it appears substantially certain that this is merely an approximation without theoretical value. Only extended researches, however, can replace it by one better founded.

The solidity of the earth is now very generally accepted, though Descartes's hypothesis of its fluidity, invented to satisfy his erroneous theory of vortices, died hard. Lord Kelvin showed from tidal phenomena that the effective rigidity of the earth is about that of a continuous globe of steel. Professor Newcomb pointed out that the Chandlerian nutation leads to the same conclusion and an almost identical value of the modulus of rigidity, and Professor George H. Darwin demonstrated that, if the earth is a viscous liquid, its viscosity must be some 20,000 times as

great as that of hard brittle pitch near the freezing point of water. From the point of view of modern physical chemistry and in consideration of Professor Arrhenius's opinions, the matter requires further consideration. In particular it is most important to know whether the earth is substantially a crystalline solid or an amorphous substance, for many modern physical chemists consider amorphous matter as liquid. This opinion is far from being established, however, and recent experiments by Mr. Spring show that mere deformation at ordinary temperatures, attended by only a very small absorption of energy, suffices to convert crystalline metals into substances exhibiting characteristics of amorphous bodies. Since Nordenskiöld's great discovery of large masses of terrestrial iron, or, rather, nickel steel, in Greenland, and the wide distribution since proved for similar metal imbedded in igneous rocks, a great amount of evidence has accumulated that a large part of the earth is composed of material indistinguishable from that of metallic meteorites. Meteoric iron is of course a highly crystalline material.

It is a very striking fact that the mean rigidity of the earth is about that of steel, for the only substance likely to occur in extensive continuous masses and displaying such rigidity at ordinary temperatures and pressures is steel itself. Nevertheless, the conclusion can not yet be drawn from the resistance to deformation displayed by the earth, that it is chiefly composed of steel. Elastic resistance is known to be a function both of pressure and of temperature, and until this function has been determined by theory and experiment, the bearing of the evaluation of rigidity by tidal action can not be ascertained.

Having shown the earth to be a solid globe, Lord Kelvin calculated its age from one of Fourier's theorems, assuming for purposes of computation an initial temperature of 7000° F. (nearly 3900° C.) and that the thermal diffusivity of the earth is that of average rock. These assumptions, with the observation that the temperature near the surface of the earth increases at the rate of 1° F. for every 50 feet of depth, lead to an age of 98,000,000 years; but on account of the uncertainty as to conductivities and specific heats in the interior, the conclusion drawn by Lord Kelvin was only that the time elapsed since the inception of cooling is between 20 and 400 million years.

Clarence King subsequently took a further important step on the basis of data determined at his request by Professor Carl Barus on the volume changes which take place in diabase during congelation, and on the effects of pressure in modifying the melting and solidifying points. Assuming that the earth can never have had a crust floating on a liquid layer of inferior density, computation leads him to 24 million years as the maximum period for the time since superficial consolidation was effected, provided that the superficial temperature gradient and conductivity are correctly determined.

These researches, together with Helmholtz's investigation on the age of the solar system, which is incomplete for lack of knowledge of the distribution of density in the sun, have had a restraining influence on the estimates drawn from sedimentation by geologists. Many and perhaps most geologists now regard something less than 100 million years as sufficient for the development of geological phenomena. Yet the subject can not be regarded as settled until our knowledge of conductivities is more complete. An iron nucleus, for example, would imply greater conductivity of the interior and a higher age for the earth than that computed by King, though probably well within the range explicitly al-

lowed by Lord Kelvin in view of the uncertainty of this datum.

The researches of Kelvin and Darwin, supplementing those of Kant and others, have left no doubt that the moon was formerly closer to the earth than it now is, and that the rotation of the latter was more rapid, involving a greater ellipticity of the meridian than it now shows. In a fluid or Cartesian earth the change of figure might have produced little effect on the structure of the planet. If the earth is chiefly a mass of crystalline nickel steel, it is very possible that such a change in the figure of equilibrium might rupture it. Since the epoch at which the earth rotated in 5 hours 30 minutes, the polar axis must have elongated by several per cent., most of it before the time of rotation was reduced to 11 hours.* Were the earth chiefly composed of forged steel, such elongation might be produced by plastic deformation; but meteoric iron is rather comparable with cast iron, or better still, with relatively brittle, unforged cement steel, and might break.

Now it is an indubitable fact that a majority of the outlines of the great oceanic basins and of the chief tectonic lines of the globe, lie nearly on great circles tangent to the Arctic Ocean and to the Antarctic continent.† These lines, or most of them, are of extremely high geological age, their main features having found expression as early as the oldest known fossils and in some cases still earlier. It appears to me very possible that these fundamental ruptures of the globe were due to the change of figure attendant upon diminution of the earth's period of rotation. Their symmetrical disposition with reference to the polar axis is unquestionable, as well as the fact that they penetrate to great depths. They must be due to some tremendous force acting axially, which actually altered the ellipticity of the meridian, since these fissures could not have been formed without modifying the shape of the globe, and the only known disturbance of this description is the change of figure referred to. On the other hand, were the earth homogeneous, such ruptures would be expected to have as envelopes small circles in latitude 45° instead of at about latitude 70°. But since the earth is not homogeneous, this discordance does not invalidate the suggestion.

Be this as it may, upheavals, subsidences and attendant contractions have been in progress throughout the whole of historical geology or the period within which fossils afford a guide to the succession of strata. The so-called contractional theory has shown itself wholly inadequate to account for the amount of deformation traceable in the rocks of the globe, nor has the extravasation of igneous rock been sufficient to account for the phenomena. To me the earth appears to be a somewhat imperfect heat engine in which the escape of thermal energy is attended by the conversion of a part of the supply into the vast amount of molar energy manifested in the upthrust and crumpling of continents. The subject will probably turn out to be accessible mathematically after certain experimental determinations have been made, and I shall return to it presently.

Orogeny or mountain building is a mere

* Compare Thompson and Tait, 'Nat. Phil.' § 772, where the rotational period and eccentricity are given for a fluid of the mass of the earth and possessing its mean density. When the period is 5h. 30m., this table gives the data for computing that the polar axis has a length equal to 0.95 of the length which it has when the period is a siderial day. For rotation in 10h. 57m. the polar axis is 0.99 times that for a day.

† In 1857 Professor R. Owen, of Tennessee, and, independently, Benjamin Peirce, called attention to the tangency of the coast lines to the polar circles (not to the coast lines of the arctic sea and the antarctic continent), each attributing the facts to the influence of the sun. In the first 'Yearbook' of the Carnegie Institution I failed to refer to these publications.

detail of the more general subject of upheaval and subsidence, but it exhibits problems of great complexity both from the experimental and from the theoretical points of view. There is no question that unit strains are often reached or even surpassed in contorted strata and in belts of slate, but the theories of elasticity and plasticity as yet developed are inadequate to deal with these strains in complex cases. An investigation on finite elastic and plastic strain is now under way in my laboratory and has made gratifying progress thus far; but this is not the place for detailed results. Something also has been done in the way of working out homogeneous finite strains in rocks, so that the general nature of joints, faults and systems of fissures and the mechanism of faulting is now fairly clear. The theory of slaty cleavage is a subject of dispute in which I have taken part. Few colleagues appear to agree with me that this cleavage is due to weakening of cohesion on planes of maximum slide, but I am not hopeless that my view will make its way to favor in time.

Seismology is a vast subject by itself, but one almost totally lacking in theoretical foundation. Seismological observations should afford the means of exploring the elastic properties of the earth throughout its interior, but the theory of the vibrations of a spheroid like the earth is not yet worked out. Meantime observations are being accumulated, but it can be foreseen that these will contribute little to elucidation until they include the vertical components of the vibrations as well as the horizontal ones. In other words, we must know the angle at which the wave emerges from the surface as well as its azimuth. The causes and conditions of earthquakes afford a separate topic of great interest. That some of them are of volcanic origin is evident; others appear to be due to paroxysmal faulting, yet there is very possibly a common underlying cause.

On no subject are opinions more divergent than concerning the origin and mechanism of volcanoes. To the ancients they were the mouths of the river Phlegethon. To those who adhere to the Cartesian doctrine they are communications with the liquid interior of the earth. Most geologists think of them as connected with hypogeal reservoirs of melted matter subsisting for indefinitely long periods of time. Finally it is conceivable that the lava may be extruded as soon as the melted mass has accumulated in sufficient quantity, somewhat as water may break through an obstructing dam after its depth reaches a certain value. The continual movements of the rocks show that they must be to some extent in a state of elastic strain, so that a given cubic mile of rock resists surrounding pressure in virtue both of its rigidity and of its compressibility. If that cubic mile becomes liquid, its rigidity is gone and the change of shape of surrounding masses may aid in its expulsion. Of course imprisoned gases, especially the 'juvenile waters' of Professor Suess, may also play a very important part in expulsion. But the more I have studied the matter, the less probable it seems to me that considerable bodies of melted lava can remain quiet for long periods of time in the depths of the earth. The influences tending to their expulsion would seem to be at a maximum immediately after the fusion of enough material to supply an eruption.

Relief of pressure is often invoked to explain fusion of lava, but it is not a wholly satisfactory cause. If a deep crack were to form, the rock at the bottom might melt indeed, but, as the crack filled, the pressure and the solidity of the source would be restored. To me, Mallet's hypothesis is more satisfactory, so far as the

explanation of fusion is concerned. Only those who have studied the minute evidence of mechanical action in mountain ranges can appreciate the evidence they present of stupendous dissipation of energy. This has not indeed been enough to fuse the rocks, but it is hard to conceive that it is always insufficient to furnish the latent heat of fusion to rocks already close to their melting point under the prevailing pressure. From this point of view, vulcanism is a feature of orogenic movement and it is to be looked for where relative motions are concentrated in zones so narrow that the local dissipation of energy is relatively intense. It is also possible that percolating waters, by reducing the melting points of rocks, sometimes bring about fusion without change of temperature. Such an hypothesis might fit the volcanoes of the Hawaiian islands where there is no known faulting in progress.

The physics of magmatic solutions is a great subject which is experimentally almost untouched, although a vast amount of geological speculation has been based upon assumed properties of magmas. It is only within a few months that even satisfactory melting-point determinations of those most important rock-forming minerals, the lime-soda feldspars, have been made. The feldspars are only one series of isomorphous mineral mixtures. Their study is fundamental and must be followed by that of the remaining class, *i. e.*, the eutectics. These, in my opinion, will lead to a rational classification of igneous rocks, themselves mixtures and incapable of logical description except in terms of standard mixtures, the eutectics.

It appears to me highly probable, for many reasons, that the magmas of the granular rocks are not liquids but stiff emulsions, comparable with modeling clay, the solid constituents (perhaps free oxides) being merely moistened with magmatic liquids. Such masses behave mechanically like soft solids; they display some rigidity and in them diffusion is reduced to a vanishing quantity. They may be ruptured and the (aplitic or pegmatitic) liquid portion may then seep into the cracks. Such a magma might be forced into minute fissures, as is the case when clay is molded to terra cotta articles and yet it would support permanently, on its upper surface, rocks of superior density. Only in such a magma can I comprehend the simultaneous growth of crystals of various minerals; for in a liquid not exactly eutectic, the formation of crystals must follow a definite order. Again, if banded gneisses and gabbros had been fluid, the bands would show evidences of diffusion which as a rule are absent or barely traceable in these rocks.

The relations between consanguineous massive rocks have occupied a large part of the attention of geologists for many years. At one time it was supposed that homogeneous liquid magmas might split up into two or more homogeneous magmas by processes of molecular flow due to differences of osmotic pressure. This process was called the differentiation of magmas. It has been shown, however, that these processes are so much slower even than heat diffusion, that they can not be efficient beyond distances of a few centimeters. For this reason, Mr. Teall,* who first suggested the application of the Soret process to account for differentiation, Professor Brögger† and others, have abandoned the hypothesis of differentiation on a considerable scale by molecular flow. Nevertheless, observations on laccolites and other occurrences leave no doubt that a single magma may solidify to different though consan-

* *Proc. Geol. Soc. London*, Vol. 57, 1901, p. lxxxv.

† 'Eruptivgesteine der Kristianiagebietes,' part III., p. 339.

guineous rocks. If the separation is not molecular, it is self-evident that it must be molar. The only molar currents readily conceivable in a body of magma are convection currents, and these, or even an equivalent mechanical stirring, would necessarily lead to fractional crystallization, a familiar process known even to the pupils of Aristotle, and which is almost unavoidable when mixed solutions solidify. This process is one of precipitation and is absolutely distinct from the differentiation (or more properly, segregation) of rock magmas, in which a single liquid is supposed to separate into two or more distinct liquids. The general conditions of the order of precipitation during fractional crystallization in accordance with the phase rule are by no means beyond the reach of discussion, and the able investigations of Messrs. J. H. L. Vogt and J. Morozewicz have a direct bearing on this subject.

A mystery which will assume greater importance as the accessible supply of coal diminishes is the origin of petroleum. There is much to be said in favor of the unpopular hypothesis of Mendeleef, supported by experiments on cast iron, that liquid hydrocarbons are due to the decomposition of the iron carbides of the terrestrial nucleus. Such vast accumulations of oil as exist on the Caspian and in the Caucasus seem incompatible with the hypothesis of animal or vegetable origin, although oils belonging to the same series as do the petroleums have been produced in the laboratory from organic materials. On the other hand, some meteorites contain hydrocarbons (which may themselves be due to the alteration of iron carbides) and there are geologists who infer that the petroleum may be derived from the mass of the earth itself.* If the origin of the oil is not animal or vegetable, the supply is very likely inexhaustible. More extended study of the connection between volcanic phenomena and the origin of asphaltic and other hydrocarbons is a desideratum.

* See H. L. R. Fairchild, *Bull. Geol. Soc. Amer.*, Vol. 15, 1904, p. 253.

Ore deposits themselves form the branch of geology which was earliest cultivated and which will never lose its interest so long as mankind remains gainful. Yet much remains to be done by experiment for the theory and practice of mining geology. The mechanism of the secondary enrichment of ores, particularly those of copper, detected by Mr. S. F. Emmons and enlarged upon by Mr. W. H. Weed, is being studied experimentally in the laboratories of the U. S. Geological Survey. A feature deserving careful experimental study is the osmotic separation of ores from their solutions by the wall rock. Many minutiæ of occurrence suggested that the walls of veins often act as a species of diaphragm or molecular filter and have a dialytic action on the ore solutions.* The origin of the ores themselves is still very obscure and will hardly be elucidated until more is known of the earth's interior. Sometimes they seem to be derived from adjacent rocks; in other cases conditions suggest that the rocks and the veins derive their metallic content from a common deep-seated source. Here, as in several other connections, Professor Suess's theory of 'juvenile waters' is very suggestive. It is held that many of the great iron deposits are due to magmatic separation. Deposition of lead ores by replacement of calcite is a known process, but takes place under unknown conditions. In some cases replacement of rock by ores appears to me to be alleged without sufficient proof. Pseudomorphosis is the only adequate test of replacement.

Erosion appears to be a subject which is capable of more exact treatment than it has received. Weathering and abrasion

* 'Min. Resources of the U. S. for 1892,' p. 156.

proceed with a rapidity which increases with the surface exposed per unit of volume.* Hence these processes lead to minimum surfaces. Therefore also the mathematics of erosion is essentially identical with that of capillarity.

Geological climates are as interesting to astrophysicists as to meteorologists and geophysicists. Messrs. Langley and Abbot appear to have evidences of recent variations in solar emanation. If these have been considerable in the course of the period of historical geology, light should be thrown upon them by the paleontology of the tropics. Variations in the composition of the atmosphere must have been very influential in determining both the mean temperature of the earth's surface and the distribution of temperature; but so also is the distribution of water. No theory of the glacial period seems generally accepted. Croll's theory is discredited. I have shown to my own satisfaction that the astronomical conditions most favorable to glaciation are high obliquity and low eccentricity of the earth's orbit,† but can not claim any extensive following. If I am right, it should be possible to obtain a definite measure of geological time in years as soon as the astronomers have completed the theory of secular variations in the planetary system so far as to be able to assign the lapse of time between successive recurrences of low eccentricity and high obliquity.

A most interesting observation, which promises much light on the past history of the globe, is that lavas and strata indurated by lavas retain the polarity characteristic of the locality in which they cooled.‡ The time may come when this will lead to determinations of the relative age of lavas, the duration of periods of eruption and possibly even absolute determinations of date.

Geology has long, and with some justice, labored under the reproach of inexactitude. As has been illustrated in the preceding pages, the science is still in the qualitative stage and almost wholly lacks the precision of astronomy. Even its most ardent students have seldom succeeded in ascertaining the quantitative relations between effects and operative causes and have been perforce content to indicate tendencies. Thus geological doctrine is far too much a matter of opinion, but this is hardly the fault of the areal geologist. The country must be mapped both for economic reasons and to accumulate a knowledge of the facts to be explained. Working hypotheses the field geologist must have, or he could not prepare his map; and he is only responsible for living up to the standard of knowledge of his time. He is continually face to face with phenomena for which physics and chemistry should account, though they have not yet done so, and must accept seeming probabilities where certainty is unattainable. So, too, Kepler's predecessors recorded facts and guessed at generalizations as best they might.

The physics of extreme conditions still awaits satisfactory exploration. The geologist turns to the physicist for help and in most cases meets with the reply: We can not tell. Astrophysics is in much the same situation. Astronomers know as little of the distribution of density in the stars or planets as do geologists. Real knowledge of the physics and chemistry of high temperatures would be as welcome to them as to us. After all, physical geology is the astrophysics of this, the only accessible planet. Geodesy, too, and terrestrial magnetism are waiting for the solution of geophysical problems. How much might be done, Lord Kelvin and Mr. George H.

* U. S. Geol. Survey, Mon. XIII., 1888, p. 68.

† *Amer. Jour. Sci.*, Vol. 48, 1894, p. 95.

‡ Brunhes and David. *Comptes Rendus*, Vol. 133, 1901, p. 153.

Darwin have shown; but there are many problems too broad and too laborious to be solved by individual effort, and these are as essential to the rounding out of the science of physics as they are to the development of geology and astrophysics.

In the brief review which precedes, I have endeavored to show that the history of the earth bristles with problems, few of them completely solved, though in many cases we have some inkling of the solution. This sketch has been drawn for the purpose of considering the strategy of a campaign against the series of well intrenched positions occupied by our great enemy, the unknown.

Generalizing the results of the sketch presented, it is easy to see that nearly all the problems suggested involve investigation of the properties of solids, or of liquids, or of the transition from one phase to the other. It is the business of the experimental physicist to establish linear relations; it is the occupation of the mathematical physicist to draw logical inferences from these relations. Each will have plenty to do in a methodical study of geophysics.

There can be no doubt that the character of the earth's interior and the physical laws which there prevail constitute the most fundamental object of geological and geophysical research, while the results of successful investigation would be immediately applicable at least to the moon and Mars. No one questions that enormous pressures and very high temperatures exist near the earth's center, while the quality of matter which constitutes the interior can not be satisfactorily determined until we know how substances would behave under extreme pressures and at temperatures approaching 2000° C. There is every reason to suppose that under purely cubical compression, dense, undeformed solids are perfectly elastic. Hence the basal problem of geophysics is to find the law of elastic compressibility. This can not be accomplished by direct means, but the task is, nevertheless, as pointed out above, not a hopeless one, and has been taken in hand. Should success be achieved, researches will follow on the variation of elasticity with temperature. This feature of the investigation will present very great experimental and theoretical difficulties, but there is no good reason to despair of success.

When the law of resistance of solid bodies becomes known as a function of both temperature and pressure, even for isotropic substances with only two moduluses of elasticity, the way will be opened to various important investigations, largely mathematical in character. It is true that thoroughly isotropic bodies are seldom met with, yet geological masses must, nevertheless, often approach closely to this ideal. Many of the most important rocks are chiefly composed of triclinic feldspars, which, indeed, occur about as abundantly as all other minerals found at the surface of the earth put together. A triclinic feldspar crystal rejoices in the full possible number of elastic moduluses, 21. Yet a large spherical mass of small, fortuitously oriented feldspars will behave to external forces of given intensity and direction in the same way, no matter how the sphere may be turned about its center, and will, therefore, act as an isotropic body. This fact is enough to show that an infinite variety of intimate molecular structures are compatible with molar isotropy.

Thus a knowledge of isotropic elasticity will suffice as a basis for testing reasonable hypotheses of the constitution of the earth's interior, taking into account its known rigidity and density. Still greater light can be thrown on this subject by including in the investigation the moon and Mars; for their masses and dimensions are

known and there seems every probability that they are composed of the same materials as the earth, though in different proportions. If a given hypothesis as to the chief constituents satisfies the known conditions of all three planets, it will doubtless find acceptance. Such a result would open the way to fresh advances in geodesy and terrestrial magnetism, and cast backward through the vista of time a ray of light on the nebular hypothesis.

Again, when the law of elasticity and the approximate constitution of the globe are known, it will be possible to work out a satisfactory theory of the simpler modes of vibration in a terrestrial sphere, and then seismological observations can be applied to determining more precisely the intrinsic elastic moduluses of the earth along the paths of earthquake waves.

It will also be practicable to examine critically the possible rupture of the globe as a consequence of change of figure and to study intelligently the simpler cases of the crumpling of strata, fissuring and other problems in the mechanics of orogeny.

The science of elasticity has had a very disappointing history. Simple as is the assumption *ut tensio, sic vis*, the attempt to solve even such seemingly elementary problems as the flexure of a uniformly loaded rectangular bar leads to insoluble equations; so that the science has been relatively unfruitful. It remains to be seen whether a truer relation between load and strain will not simplify formulas and increase the applicability of algebra to concrete cases.

From an astrophysical point of view the dialytic action of mineral septa is unimportant, but it is very interesting in its bearing on metamorphism and ore deposition, and may readily contribute to economic technology.

The relations of viscosity to the diffusion of matter have not yet been elucidated even for ordinary temperatures. This subject is one of much importance in connection with the genesis of rock species, and of course it should be studied at 10° before undertaking researches at 1000°.

High temperature work is essential even to the investigation of the elastic problem and it is almost a virgin field. Even thermometry is very imperfect above the melting point of gold, though it is destined soon to become exact at least as high as 2000°, a range which will probably suffice for geophysics. But we are also in almost total ignorance of the extent to which the laws of physics, studied at ordinary temperatures, prevail at one or two thousand degrees. One of the less difficult problems of this group is that of thermal conductivity and specific heat of solid bodies at high temperatures. For the principal metals this is already known as far as 100°, but not for rocks or minerals. It would be especially desirable to have such determinations for granite, basalt and andesite, the last representing the average composition of the accessible part of the lithosphere.

It seems to me that when the thermal diffusivities are known for these rocks, over a range of a thousand degrees, the question of upheaval and subsidence can be attacked with a good prospect of success. A cooling sphere is conceivable in which the distribution of thermal diffusivity is such that the flow of heat would be 'steady,' in Fourier's sense, and thus accompanied by no superficial deformation. With any other distribution of diffusivities, deformation would occur, and the globe would act as an imperfect heat engine, the work done being that of upheaval or subsidence. Now when the assuredly variable value of diffusivity for the materials of the globe is known, the mathematical conditions for steady flow can be worked out, and if these are not consistent with the facts of the

globe, a *vera causa* for upheaval will have been found, which may lead to further and more detailed conclusions. It should also either elucidate or simplify the subject of the fusion of magmas and their eruptive expulsion.

The data for constitution and thermal diffusivity will readily be applicable to the problem of the earth's age and will yield a corrected value of the probable lapse of time since the initiation of the *consistentior status* of the Protogæa.

The most difficult field in geophysics is the study of solutions at high temperatures. This is largely because both methods and apparatus require to be invented. When work of this kind was undertaken in the laboratory of the Geological Survey, three years since, no furnace existed in which pure anorthite could be melted and a trustworthy determination of the temperature of fusion made. For the study of aqueo-igneous fusion, which must, of course, be performed at considerable pressures, extremely elaborate preparation is necessary; indeed, all attempts hitherto made in this direction have been only very partially successful.

Were it not that the number of important rock-forming minerals is small, the study of igneous solutions for geophysical purposes would be an almost hopeless task. The feldspars, the pyroxenes, the amphiboles and the micas appear to form isomorphous series and must be studied as such. They, with quartz, make up nearly 93 per cent. of the igneous rocks, nepheline, olivine, leucite, apatite, magnetite and titanium minerals substantially completing the list which enter into these rocks in sensible proportions. After the melting points of the minerals have been determined and their isomorphism has been studied, the most important research to be undertaken is that on their eutectic mixtures. Other features, however, must receive attention, such as their latent heat, ionization, viscosity and diffusivity. Immensely interesting will be the study of melts into which hydroxyl enters as a component and which may turn out to be emulsions rather than solutions. Such researches will constitute a most substantial addition to physical science and, as pointed out above, offer a good prospect for the rational classification of rocks.

Enough has been said to show how closely geophysical researches interlock. Researches at high temperatures must accompany investigations at common temperatures, physics must be supplemented by physical chemistry, mathematical ability of the highest order must be called upon at every step to elucidate difficulties and to draw inferences capable of being again submitted to inquiry, and some geological knowledge, too, is requisite to appreciate the bearing of results and to indicate the questions of importance. No human being has the length of days, the strength, the skill or the knowledge needful to undertake, without help, the investigation of geophysics as a whole. Only a few of the topics touched upon in the earlier pages of this essay are independent of cooperation; for instance, the astronomical conditions favorable to glaciation and perhaps the application of the mathematics of capillarity to the problem of erosion. On the other hand, the list of geophysical problems requiring cooperation could be almost indefinitely extended even now, and will be supplemented when the most pressing questions approach their answers.

Organization increases efficiency in scientific work as much as in technical pursuits, though it has seldom been attempted. Instances in point are the U. S. Geological Survey, the Reichsanstalt and astronomical surveys of the sky. Geophysics, then, is

too difficult a subject to be dealt with excepting by a well organized staff, working on a definite plan resembling that indicated above. The tastes and convenience of individuals must give way to the methodical advancement of knowledge along such lines that the work of each investigator shall be of the utmost assistance to the progress of the rest.

Work in geophysics is already in progress in this country, thanks to the appreciative sympathy of Director Walcott, of the Geological Survey and the liberality of the Carnegie Institution, by members of my staff and in part under my direction. Messrs. A. L. Day and E. T. Allen have made an excellent series of determinations of the melting points of the triclinic feldspars and studied their other thermal properties. They are now preparing to make experiments in aqueo-igneous fusion. Mr. C. E. Van Orstrand has made a novel application of the theory of functions to elastic problems and has reduced several series of important observations on elastic strains for comparison with theory. Dr. J. R. Benton is occupied in experimental investigation of elastic strains in various substances. The men engaged in these researches are able and devoted to their work, but they are too few in number, and they are required to make determinations of the most delicate character in an office building standing in the busiest portion of Washington, where the walls are in a state of incessant tremor and where there is no suggestion of uniformity of temperature. Under such circumstances the results of observation can not be of the most refined character and must be obtained at great expense of time and effort.

Most of the great physicists of the world have expressed their interest in geophysics and their belief that the time is ripe for its investigation. Geologists are eager for its results, but no government can undertake investigations so remote from industry as this. I do not think I can more fitly conclude this paper than by quoting a resolution introduced by Mr. S. F. Emmons at Vienna a year ago. It was passed by acclamation by the Geological Congress, after a ringing speech by Professor Suess, and it expresses my own views most accurately.

EMMONS'S RESOLUTION.

"It is a well-known fact that many of the fundamental problems of geology, for example those concerning uplift and subsidence, mountain-making, vulcanology, the deformation and metamorphism of rocks and the genesis of ore deposits, can not be discussed satisfactorily because of the insufficiency of chemical and physical investigations directed to their solution. Thus, the theory of large strains, either in wholly elastic or in plastic bodies, has never been elucidated; while both chemistry and physics at temperatures above a red heat are almost virgin fields.

"Not only geology but pure physics, chemistry and astronomy would greatly benefit by successful researches in these directions. Such researches, however, are of extreme difficulty. They would require great and long sustained expenditure as well as the organized cooperation of a corps of investigators. No existing university seems to be in a position to prosecute such researches on an adequate scale.

"It is, therefore, in the judgment of the Council of the Congrès Géologique International, a matter of the utmost importance to the entire scientific world that some institution should found a well-equipped geophysical laboratory for the study of problems of geology involving further researches in chemistry and physics."

GEORGE F. BECKER.

THE DOMAIN OF PHYSIOLOGY AND ITS RELATIONS TO MEDICINE.*

PHYSIOLOGY is of medical parentage, was reared by medical men and is still housed and fed by medical faculties. Still it is medicine against which its frequent declaration of independence is directed. Medicine is a practical science and is too inexact, and physiology wishes to be a pure, exact science. It, therefore, tries to keep aloof from medicine and manifests a longing for association with or, still better, for a reduction to, physics and chemistry. It urges, furthermore, that the affiliation with medicine binds physiology down to only one species of animal with intricate, complicated conditions, while it would be more beneficial to physiology if it would direct its energies towards a study of monocellular organisms where the conditions are so simple.

Permit me to discuss briefly the domain of physiology and the importance of its relations to medicine as they present themselves to my mind. There can be no doubt whatsoever that physiology has a perfectly legitimate object entirely of its own. Perhaps I may elucidate this statement in the following crude way. All natural phenomena impress us in two ways—as matter and as force. The phenomena are either inanimate or animate. The studies of inanimate matter are to be found in mineralogy, crystallography, in a part of chemistry, etc. The studies of the forces or energies of inanimate phenomena are carried on by physics and physical chemistry. In the fields of living phenomena, matter is studied by gross and minute anatomy and by descriptive zoology and botany, or in short by morphology. The studies of the forces, the energies or the functions of living matter, are the proper domain of physiology. Now this definition permits a few deductions. All these four divisions are bound, as sciences, to have something in common in their methods of investigation; they must employ the inductive method and must strive to reach in their results that degree of certainty which the nature of each individual science permits it to attain. But the four divisions differ greatly from one another; each one has its own subjects and laws and its own problems, which have to be solved by methods peculiarly adapted for each division. It is certainly clear to every one that it can not be the essential task of animal morphology to reduce itself to mineralogy because it can be demonstrated that some anatomical objects contain lime and other mineral substances. It seems to me it ought to be also clear to every one that it can not be the sole task, and not even the essential task, of physiology to reduce itself to physics and chemistry because some or many of the living phenomena are governed to some extent by known laws of physics and chemistry. Physiology has to study the functional side of life, and in the attempts to elucidate its complex phenomena it certainly has to employ also the known facts of physics and chemistry. But if we would confine the domain of physiology to such parts only which can be interpreted by the laws of physics and chemistry of to-day, we would have to give up nine hundred and ninety-nine out of a thousand of the phenomena of life as still inappropriate for physiological study. The four divisions of the natural sciences are closely interwoven and each one can, of course, profit by the experience of the others. Boyle, Mayow, Priestley, Lavoisier and others attempted to unravel the nature of oxygen, nitrogen and carbon dioxide gas by the aid of experimental studies of the physiology of respiration. The physicist or the chemist employs any method which would help him

* Chairman's address at the Section of Physiology of the World's Congress of Arts and Science, at St. Louis, September 23, 1904.

to shed light upon his subject, but physics and chemistry have methods peculiar to themselves and that is the secret of their great success. And so it should be with physiology. However, when physiology broke away from medicine, it ran into the arms of physics and chemistry and is still largely there. The early successes which have attended the new venture, which, by the way, is the case with every new venture, led to the conception that this is the most desirable, the most natural union. An analysis, however, of the work in animal physiology in the last few decades will show the fact that the too great gravitation towards physics and chemistry prevented the development in many directions of a purely physiological character.

I contend that physiology is an independent science with a clear outline of its domain, but it ought to direct its declaration of independence not only towards medicine, but also towards such exact sciences as physics and chemistry.

As to the standard of precision and exactness to be required of physiology, let me say this. Certainly no physiological problem can be solved with that exactness, with that absolute reliability which is now the standard for a good many problems in physics and chemistry. Above all in the studies of the energies of life we lack the controlling factor of synthesis. If we can produce synthetically urea or sugars or other dead constituents of a dead or living body, we can not yet make synthetically the smallest living organ of the smallest homunculus. But what of it? Each science has its own degree of attainable exactness. Physics and chemistry have one standard and paleontology or geology is bound to have another standard of exactness. There is no one standard of exactness for all sciences. The scientific demand upon work in any science is to strive for that degree of exactness which is attainable in each specific field of investigation.

I contend, further, that physiology ought not and can not be properly developed upon the basis of a morphological unit. We might just as well attempt to put up the mineral crystals as a basis for the study of physics.

I may say, further, that in my opinion the knowledge of vital energies would progress more rapidly if we would be guided in our investigations by the view that the actual processes in the phenomena of life are of a very complex nature. The desire to reduce the multiplicity of phenomena to a few simple principles is a philosophical importation of a psychological origin. Certainly premature attempts to offer simple interpretations for complex phenomena have often been an obstacle for a further development of our knowledge of the actual processes.

Physiology, however, may take some useful hints from the other sciences. It may learn from such exact sciences as physics and chemistry that the exactness and dignity of a science do not suffer by coming into intimate contact with the necessities of daily life. On the contrary, we find that those chapters of physics and chemistry whose results found practical application, are best developed. The contact of a science with life and its actual necessities works, on the one hand, as a stimulus to investigation, and, on the other hand, as a corrective against an indulgence in mere hobbies. The experimental method as such is no talisman against such scholastic degeneration. A study of the literature of the last few decades will show that physiology, too, could well stand such a corrective.

Physiology could also learn from morphology that a special attention to the human being does not necessarily lead to a neglect of the uniform study of the entire

animal kingdom. The marvelous complete studies of gross and minute human anatomy, which was of such immense service to pathology and surgery, was in no way an obstacle to the brilliant development of the broad science of zoology.

There is, however, one difference between the studies of the energies of inanimate phenomena and the studies of the vital energies to which I would like to call special attention. For physics there is only one kind of energies; they are all normal. If the physicist meets with conditions which apparently do not agree with some established law, he does not transfer these conditions to a pathologist in physics for further investigation. On the contrary, he is only too glad to have such an opportunity; it usually leads to an elucidation of the old law, or still better, an entirely new law might be discovered. When Kirchhoff was surprised by the apparently contradictory fact that by the addition of the yellow light of sodium to the sunlight the dark *D*-lines in the spectrum instead of becoming lighter became still darker, he did not turn away from the problem. On the contrary, he was glad of this opportunity; in fact, as he stated once, he was longing to meet such a complete contradiction. The result was the establishment of the law of the proportion between emission and absorption of light and the creation of the nearly new science of spectral analysis. Or to quote a more recent instance, the exceptions to van't Hoff's law of osmosis which were met with in salt solutions and which had been displayed by some as a proof against the validity of that law, served Arrhenius as a basis for the establishment of the far-reaching law of electrolytic dissociation. It is totally different, however, with physiology. Its domain is, as we saw above, the study of the functional side of living phenomena. Here, however, we find the artificial and unsound distinction between normal and abnormal functional phenomena. Physiology set up some laws; and if conditions appear which do not fit in with these laws, physiology declines to deal with them, it refers you to medicine. Are the laws governing the vital functions under pathological conditions actually different from those controlling the functions in health? Certainly not. The laws which physiology establishes must be capable of covering the functional phenomena in all conditions of life. The apparent exceptions in disease should serve in physiology, as in physics, to unravel the real nature of the laws governing the functions of living phenomena, whether they occur in health or in sickness. For instance, the processes occurring while the body is in a state of fever should give a clue to the understanding of the mechanism of the constancy of the elevated temperature of warm-blooded animals. Or the conditions prevailing when urine contains albumin should be seized as a means of studying the remarkable phenomenon in the normal urinary secretion, namely, that of all the endothelial cells of the body the kidney endothelia alone do not permit normally the passage of albumin. Or the conditions of the blood and the lung tissues in pneumonia could serve as an aid in studying the factors concerned in the formation of fibrin. And so on and so on in many thousand instances of daily occurrence. Some very important discoveries in physiology were thus recently brought to light through medical experience and by medical men, with hardly any aid from physiology. The anatomy of the cases of myxœdema and cretinism and the results of the complete removal of the thyroid gland for goitre revealed the physiological importance of that ductless gland for which physiologists, with one single exception, had no interest. This discovery helped at the same time to establish and to introduce

into physiology the far-reaching conception of internal secretion. Furthermore, the observation of Bouchard, Lancereaux and other medical men of the occurrence of a degeneration of the pancreas in cases of diabetes mellitus, led to the discovery, by two medical men, of the remarkable fact that the complete removal of the pancreas in dogs leads to diabetes. This discovery demonstrated at the same time the further principle that even glands with a distinct external secretion have besides a physiological importance for the body by virtue of their internal secretion. In the long list of workers on this subject we hardly find a single physiologist.

I could quote a good many more instances in which medical studies brought out important physiological facts and how physiology is slow to avail itself of such golden opportunities.

The physicists are only too glad to meet with exceptions; the physiologists run away from them. Is there any well-founded justification for such a course in physiology? I believe none. I believe it is simply an erroneous position. It would lead me too far to attempt here a discussion of the causes which led to this position in physiology. But I say without hesitation that this position is deplorable, is harmful to physiology as well as to medicine. Animal experimentation is the essential method of developing physiology. Now then nature makes daily thousands of experiments upon man and beast and physiology refuses to utilize them for its own elucidation. I feel quite sure that a study of the functional processes in pathology, or at least the systematical taking up of physiological problems indicated by pathological processes, by minds naturally endowed and properly trained for physiological studies, would greatly elucidate the proper sphere of physiology itself and would at the same time be of incalculable value to pathology and medicine.

And medicine is greatly in need of such a physiology. I am afraid that the actual situation in medicine is not fully grasped even by a great many of its enlightened disciples. To state the critical point in a few words: The actual disturbance in most of the diseases is primarily of a functional nature, but the essential part of the present knowledge in medicine is morphological in its character! This discrepancy is due to the uneven development of the sciences of medicine. When the empirical art of medicine awoke to the necessity of acquiring a scientific basis, it found ready for its disposal an already well-defined precise anatomy, but only a vague, incoherent physiology. It set out and continued to work in the precise lines of anatomy, in which it attained a marvelous completeness. By this step, however, morphology became the dominant factor in medicine and the definition of a disease became inseparably coupled with that which was found in the body after it succumbed to the disease. When at a later period physiology also became a precise science, it broke away at the very onset of its regeneration from medicine; it wished to be exact, to be a pure science, and thus gained no influence upon pathology, which it refused to study. So it came about that medicine is made up of a complete knowledge of the anatomical conditions after death, of nearly a complete morphology of the symptoms of the disease during life, but of only a vague, makeshift mechanical interpretation of the functional disturbances during the actual course of the disease. The last decades have seen the birth and marvelous growth of the knowledge of the ætiology of disease. Animal and vegetable invaders were recognized as the essential cause of many diseases. But the study of the functions of the body whose lot it is to grapple with the invaders

received only a secondary attention, and that again essentially from morphological quarters. At the present time still more knowledge is being diligently added to the stores of medical wisdom. Chemistry has taken a powerful hand in the studies of physiology and pathology and is attaining brilliant results. But we should not be misled. The studies are essentially morphological in their nature. It is physiological and pathological chemistry, and but very little chemical physiology and pathology. Even if the hopes of the new school of brilliant chemical investigators will, indeed, be realized, viz., that in a not far off future they will know the structure of proteids and all their constituent bodies, it will be the knowledge of the proteids of the dead bodies, it will be a brilliant post-mortem chemistry. Living animal matter, however, is something else than dead proteids, as living plants are something else than carbohydrates, although the knowledge of the latter has already reached the ideal stage where some of them can be produced synthetically. No, a study of life, normal and abnormal, is essentially a study of energy, of function; of course, the knowledge of the underlying morphology, dead or living, is a prerequisite for such studies. And let me state right here that there seems to be a difference in the make-up of the human mind with regard to the different studies. Some are more apt and better endowed to grapple with the problems of energy, and others again have natural talents for the science of morphology. Only few, however, have the good fortune of becoming educated in the lines of their natural endowments, and still fewer have the genius to work out their natural destinies against all odds, against all education and training. Now the men who did and who now do the original work in the medical sciences received their training in the studies of medicine, four fifths of which is profoundly developed, magnificent morphology. We can not wonder, therefore, that most of the original contributions to the medical sciences are essentially of a morphological character. Even in the very recent brilliant additional departments of medicine, in bacteriology and chemistry, the research work is, as already stated above, for the most part of a morphological stamp. It is true that a few men of genius in medicine, Cohnheim for instance, broke their acquired chains and made an attempt to study pathology from a functional point of view. Such attempts, however, were not many and their permanent influence is not extensive. What is now termed general pathology or even pathological physiology consists, in the first place, of a collection of histological, bacteriological and chemical facts of a general but essentially of a morphological nature, including at the same time the applications of a few well-established physiological facts to pathology and a few results from direct experimentation in pathology. That is not a study of physiology under pathological conditions, and certainly not a study of general physiological laws which can be stimulated by and derived from a study of pathological processes. And it is just this kind of study which is missing, and which could be developed only by a purposeful and concerted action of the men who have a training in the study of the functional side of life, among whom there are surely many who have a natural endowment for such studies.

The following review of the present situation in medicine will show us the place left vacant by physiology and the disastrous consequences. The studies of pathological anatomy extend over all divisions of medicine, are lucid and nearly complete. Diseases which are exclusively due to palpable anatomical changes are quite well understood. Their harmful effects are, for

the most part, of a mechanical nature. In proportion as they are understood, these forms of disease become amenable to an efficient treatment; it is mechanical, it is surgery.

The studies of the ætiology of diseases revealed and continue to reveal many of the foreign originators of disease, the animal and vegetable invaders of the living organism. This new and lucid knowledge led again to some effective measures in the treatment of diseases, it led to clear plans in preventive medicine, it gave means to the surgeon to enter with impunity into the interior of living organisms, and in a few instances it discovered actual remedies for non-surgical diseases.

But most diseases are something more than mechanical disturbances, or exclusively anatomical changes. There is, in the first place, that large group of so-called functional diseases which has no pathological anatomy, and for which clinicians have very little interest. But even those numerous diseases in which the post-mortem examination revealed distinct anatomical changes were only results of the advanced stage of the disease. The disease during life consisted primarily surely in disturbances of a functional character, in reactions to foreign causes, reactions of living energies, the physiology of which we have possibly as yet not even an inkling of. The so-called organ physiology which appears to the teachers of physiology to be so extensive that it can hardly be taught to students of medicine in one year's lectures, is of astonishingly modest assistance to the understanding of the actual processes of disease. For instance, in the present knowledge of the entire section of the diseases of the respiratory tract, physiology has hardly any share. The knowledge of the few physiological principles which are applied there can be acquired in one hour's instruction. The extensive knowledge in this chapter of pathology is essentially of a morphological nature. Do the functions of the involved organs take no part in these pathological processes? Most certainly they do; but we know too little of it, and the clinician passes over the gap with some makeshift mechanical explanations. The same is true in neurology; in fact, in nearly every chapter of internal medicine. It is impossible to dwell here on the particulars of our subject. What is the result? First-class clinicians employ their brilliant faculties in continually developing the morphology of diseases and their diagnosis. But treatment? There is either a nihilism pure and simple, or some sort of a symptomatic treatment is carried on with old or new drugs upon a purely empirical basis. Or there is a great deal of loose writing upon diet, air, water, psychotherapy and the like, and a great deal of semi-popular discussion in international, national and local meetings and popular prize essays on the best methods of treatment—with a net result of only a very modest actual benefit for the poor patient, who in addition to his affliction has now to feel the tight grip of the modern health officer. There is no efficient treatment of internal diseases in any way comparable with the specific surgical treatment of mechanical diseases, no specific quelling, correcting or curbing of primarily functional disorders. And there never will be such a specific functional therapy before there will be a physiology which, like physics, will be only too glad to meet with many exceptions in order to properly understand all the rules by which the energies of all grades of living phenomena are guided.

S. J. Meltzer.
Rockefeller Institute.

SCIENTIFIC BOOKS.

Blood Immunity and Blood Relationship. By George H. F. Nuttall, M.A., M.D., Ph.D., University Lecturer in Bacteriology and Preventive Medicine, Cambridge. In-

cluding original researches by G. S. GRAHAM-SMITH, M.A., M.D., D.P.H., Camb., and T. S. P. STRANGEWAYS, M.A., M.R.C.S. Cambridge University Press. 1904.

The recent study of the mechanism of immunity begun by Bordet and Ehrlich has opened an entirely new chapter in biological science and has already yielded some practical results of great interest and importance. None of these practical aspects of the new science has been so prolific of immediate results as the study of the precipitins. These specific proteids are developed in the animal body by injection of foreign proteids, as blood-serum, milk, bacterial emulsions, etc., and their presence in the blood of the treated animal is indicated by the fact that when the blood-serum is added *in vitro* to the alien blood or to the bacterial emulsion used in the injections, a precipitate occurs from the union of the newly-developed precipitin and the foreign proteid. The precipitins are highly specific, acting only on the proteid injected, so that when a rabbit has received several injections of human blood, its serum precipitates the proteids of human blood, but not those of beef, sheep or any other lower animal blood. The first application of this principle has developed the medico-legal serum test for blood which has become fully established as a reliable test in forensic cases.

Nuttall and his associates were among the first to see the possibility of establishing by means of the precipitin test a far more accurate scheme of relationships in the animal kingdom than has been possible by any other method, and the results of their studies, extending over a period of three years, are presented in detail in the present volume.

The elaborate scope of the work may be judged by the fact that Nuttall himself prepared in the rabbit anti-sera for the bloods of thirty different animals and records no less than sixteen thousand tests on the blood of nine hundred animals. Only the barest outline of the many important results of this extensive work can here be indicated.

In general, Nuttall succeeded in establishing a close blood relationship in different classes of animals which zoologists have grouped together chiefly on anatomical grounds. Among the most interesting of these relationships is that between the Anthropoidea. It is a somewhat startling verification of the consanguinity of man and the higher monkeys that the blood of the chimpanzee gives 90% as much precipitum with humanized rabbit serum as does the blood of man himself, while the blood of lower monkeys yields only one fourth or one third as much. The chimpanzee thus appears much more nearly related to man than to the common Rhœsus monkey. Another interesting result is the observation that anti-pig serum is remarkably diffuse in its action, affecting considerably the blood of primates and showing that the porpoise has correctly been called the 'sea hog.'

Numerous conflicting results are recorded, which is not a matter of surprise, considering that the specimens of blood were collected on blotting paper, often under great difficulties, and sent by mail from nearly all parts of the world. As the author states, only a beginning of the study of blood relationships has been accomplished and much remains to be done in determining the exact standing of different animals in their respective classes. It is of fundamental importance to have established the fact that the precipitin test is universally applicable as a method of zoological rating, and may have much influence in elucidating many problems of evolution. It may be suggested that new points of view may, perhaps, be secured and former results be effectively controlled by comparing the action of anti-sera for the same blood prepared in other animals as well as in the rabbit, which is the animal almost exclusively employed by workers in this field.

The method of estimating the degree of reaction by measuring the bulk of precipitate is one of the many important contributions of the author to the technics of serum work.

Graham-Smith contributes an extensive study of anti-sera among lower vertebrates and arthropods, and an important critical study of the medico-legal application of the test. This investigator more than any other has demonstrated the possible sources of error in the medico-legal use of the test, so that

familiarity with his work is essential for any one who undertakes the employment of the serum test for human blood.

Not the least valuable and laborious feature of the volume is the very complete critical summary of the literature of the precipitins, for the preparation of which the thanks of all students of the subject are due. J. EWING.

Praktikum für morphologische und systematische Botanik, Hilfsbuch bei praktischen Uebungen und Anleitung zu selbständigen Studien in der Morphologie und Systematik der Pflanzenwelt. By KARL SCHUMANN, late curator of the Royal Botanical Museum at Berlin. Jena, G. Fischer. 1904.

Professor Karl Schumann's posthumous text-book of morphological and systematic botany is a stout imperial octavo of six hundred pages. The work was largely in type at the time of Professor Schumann's death, and in accordance with his wish it has been brought to completion under the editorial supervision of his able colleague, Professor Max Gürke. The plan of the volume is to illustrate the facts of the morphology and classification of the flowering plants by describing in considerable detail seventy-nine species, selected to typify the most important families and arranged in the general sequence of their flowering seasons. The work is the result of wide experience and intensive study in the fields covered. By its wealth of carefully recorded facts, its conscientious detail and perfect lucidity it must at once command respect. As a laboratory guide, however, it will scarcely prove successful, at least in America. Of the plants treated, the majority are European species not generally familiar, even in cultivation, on this side of the Atlantic. It is true, the descriptions would in many instances apply with a fair degree of accuracy to nearly related American species of the same genera, yet the correspondence would be imperfect and perhaps misleading. Furthermore, students of one nationality doubtless differ somewhat in their psychological traits from those of another. It may well be, therefore, that a type of text-book suited to one nation may not be equally adapted to another. In fact, it is the general experience in America that a laboratory guide in order to be effective in holding the attention of the student and stimulating his interest should present its subject not by long and full descriptions, but rather by indicating methods of observation and leading the student to examine and discover for himself.

One of the chief defects of the book under discussion is that, dealing as it does with an arbitrary number of unrelated species, it would leave the student with but a vague idea of the relative systematic importance of the morphological features examined, since in general he would be unable to distinguish the traits characteristic of and restricted to the particular species from the more general features common to other plants of the same genera and families. There is, in fact, little effort to correlate and draw together by any form of systematizing or generalization the morphological characteristics, which are described separately for each of the seventy-nine species.

The introductory matter is very brief, dealing chiefly with the simple microscope and the ordinary methods of plant dissection. The closing pages are, however, devoted to some excellent hints to students entering upon monographic and floristic work. There is also a list of the chief floras of different lands. This seems to have been prepared with some haste, since it contains a number of clerical or typographical errors. Surely a work which urges (p. 578) the careful verification of all citations should not set the poor example of mangling names of well-known authors, as, for instance, 'J. W. Hooker' (p. 599), 'Nathaniel Britten' (p. 600), or 'N. B. Hemsley' (p. 602). It is fair to say, however, that many such trifling slips should be pardoned in a large and posthumous work.

The volume is copiously illustrated from drawings on granulated paper executed by the author's daughter. The figures are exceedingly clear and bear ample evidence of fidelity to nature. It is a pleasure to notice that they are all fresh and original, none having been borrowed from any other work.

B. L. R.

SCIENTIFIC JOURNALS AND ARTICLES.

The Botanical Gazette, for October, contains the following articles: Bradley M. Davis has discussed the relationships of sexual organs in plants, presenting their classification based upon certain evolutionary principles and also suggesting a terminology that is more precise.—Bruce Fink has contributed another paper upon the 'ecology' of a lichen society, this time considering a curiously isolated society upon a sandstone riprap in Iowa.—J. Y. Bergen has given some results of his observations in Italy on the transpiration of sun leaves and shade leaves of the olive and other broad-leaved forms, showing in general that xerophytic leaf structure is not always incompatible with abundant transpiration.—A. S. Hitchcock, in his fourth paper, entitled 'Notes on North American Grasses,' discusses *Poa serotina* Ehrh. and *P. flava* L., and also the genus *Digitaria Heist.*—F. L. Stevens has made a further contribution to our knowledge of oogenesis and fertilization in the genus *Albugo* by presenting his results with *A. Ipomoeae-Panduranae.*

THE September issue of the journal of *Terrestrial Magnetism and Atmospheric Electricity* has as its frontispiece the portrait of Alexander von Humboldt, and contains besides notes and abstracts and titles of recent publications, the following articles:

N. UMOW: 'Die Construction des Geometrischen Bildes des Gauss'schen Potentials, als Methode zur Erforschung der Gesetze des Erdmagnetismus.'

L. A. BAUER: 'The Physical Decomposition of the Earth's Permanent Magnetic Field, No. IV.' a. Introductory Note; b. Secular Motion of a Free Magnetic Needle; c. Vertical Earth-Air Electric Currents; d. Residual Magnetic Field and Diurnal Variation Field.

L. A. BAUER: 'Appeal for Cooperation in Magnetic and Allied Observations during the Total Solar Eclipse of August 29–30, 1905.'

W. VAN BEMMELEN: 'Magnetic Survey of the Dutch East Indies.' (Second Communication.)

J. DE MOIDREY: 'Note sur l'Amplitude de l'Oscillation diurne de la Déclinaison Magnétique et son Inégalité Annuelle.'

G. W. LITTLEHALES: 'Magnetic Declinations by Peary in the Arctic Regions, 1900–02.'

W. F. WALLIS: 'Principal Magnetic Disturbances recorded at Cheltenham Magnetic Observatory, May 1–August 31, 1904.'

DISCUSSION AND CORRESPONDENCE.

THE STOMACH STONES OF THE PLESIOSAURS.

APROPOS of Dr. Eastman's letter on the 'stomach stones' of the plesiosaurs, published in SCIENCE, No. 510, p. 465, permit me to state that there is not a shadow of doubt that the plesiosaurs, both Cretaceous and Jurassic, had the habit of swallowing such stones. At least thirty instances are now known of the occurrence of the very peculiarly worn pebbles between the ribs or with the remains of plesiosaurs in both Europe and America. The fact was first published by Professor Seeley, of England, in 1877, and Seeley it was who first suggested their use in digestion and the possession of a 'gizzard' by these animals. This absolves Mr. Brown. Crocodiles are frequently reported to have like habits, and Buckland says that the Arabs determine the age of these animals by the number of the stones found in the stomach, one being swallowed each year! Similar pebbles have also been found with the remains of extinct crocodiles, and St. Hilaire gives a minute account of such instances. I need not say also that there are various accounts in the literature of like habits possessed by some of the seals and sea-lions. I doubt not that the habit was an intentional one with the plesiosaurs, nor do I think that Dr. Eastman would doubt either, had he ever collected the remains of these animals in the field. That the plesiosaurs had a gizzard-like stomach I do not believe, but I see nothing startling in the suggestion—with due apologies to Dr. Eastman. His argument, that, if the plesiosaurs were of lithophagous proclivities, other reptiles should be expected to gorge themselves on a like mineralogical diet is hardly pertinent. The prairie chicken has the regulation gallinaceous gizzard, and, therefore, the sage hen should have one. But it has not. *Ab uno disce omnes* is not always safe. And, it must be remembered, all reptiles have stomachs with thick muscular walls.

S. W. WILLISTON.

SPECIAL ARTICLES.

AN ARTIFICIAL ROOT FOR INDUCING CAPILLARY MOVEMENT OF SOIL MOISTURE.

The rate at which a plant is able to secure water from a soil, under any given conditions, depends upon two factors: (1) The pulling force which a plant is able to exert upon the water in the soil, and (2) the capillary force with which the soil holds the water which it contains. Under a condition of equilibrium, this latter force could be expressed in terms of the curvature of the capillary surfaces. When the water in the soil begins to move, however, there is introduced, in addition to the static pull of the curved capillary surfaces, a resistance to the movement or translocation of the water over the surface of the soil particles. This resistance, which obviously depends upon the thickness of the film, must be taken into consideration in all questions relating to the rate of movement of the capillary moisture in soils.

In order to determine the rate at which a given soil with a given moisture content is able to supply moisture to the roots of a plant, one must create in the soil at some point a pulling force analogous to the action of the plant root. This may be done in several different ways:

1. The surface of the soil may be exposed to evaporation, thus producing an upward movement of the water from the lower portions of the soil. This method is open to serious objections. The surface soil soon becomes air-dry, unless the water content is kept abnormally high, so that evaporation must take place more or less from within the soil mass, which leads to indeterminate conditions. Furthermore, previous experiments have shown that the distance through which water will rise in a dry sand is only one fourth the distance through which a vertical movement will take place in moist sand.* From these facts it is evident that the capillary movement induced by a dry surface soil is not representative of the capillary movement in the soil surrounding the active roots of a plant, where the soil grains are covered with water films.

2. An osmotic cell buried in the soil may be used to produce an inward movement of the soil moisture towards the cell,* provided the osmotic pressure of the cell solution is greater than the capillary pressure of the soil moisture.† Unfortunately, the rate at which water diffuses into a cell of this kind is so slow as to preclude the possibility of taxing the soil by this method, except under conditions approximating drouth. This, combined with the changes in concentration which take place at the inner wall of the cell as water enters, and the difficulty experienced in preparing cells capable of withstanding high pressures, makes the method in general unsuitable for investigating the rate of capillary movement. When the moisture content of a soil is reduced to such an extent that the rate of movement is extremely slow, the osmotic cell furnishes a very beautiful means of producing in the soil a capillary pull of known magnitude.

3. The method which we are about to describe avoids the errors and difficulties incident to the two methods outlined above. The apparatus consists of a close-grained unglazed porcelain tube, closed at one end, and provided at the other with a tubulure, by which it can

* Briggs and Lapham, Bull. 19, Division of Soils, U. S. Dept. of Agri., 1900.

* Cameron (Bull. 22, Bureau of Soils, Dept. of Agri., 1903) has shown experimentally that when an osmotic cell, having a calculated osmotic pressure of 36 atmospheres, is buried in a soil, there is an inward or outward movement of water depending upon the moisture content of the soil.

† The capillary pressure of the soil moisture is due to the existence of curved water-air surfaces within the soil which tend to contract and thus produce a pressure outward along the normal to the water-air surface. This surface can actually move outward only by drawing in additional water from surrounding capillary spaces. If the moisture in the soil is in equilibrium the curvature of all the water surfaces at a uniform level is the same. The pressure exerted by the capillary surfaces depends upon the curvature and the surface tension. When the moisture content of the soil is diminished, the curvature, and consequently the capillary pressure, is increased. See Bulletin 10, Div. of Soils, U. S. Dept. Agri., 1898.

be connected to an exhausted receiver. When a tube of this kind is moistened, so that the pores are filled with water, and the tube is protected from evaporation, it can be exhausted to a pressure equal to the vapor pressure of water, and, if connected to a two-liter receiver, it will maintain that difference in pressure for a day or more without sensible loss. It is evident that under these circumstances the curvature of the capillary water surfaces on the outside of the tube must exceed the curvature of the capillary surface on the inside of the tube by an amount sufficient to produce a pressure of nearly one atmosphere.

Suppose now that a tube of this kind be buried in a moist soil having a moisture content sufficiently high to reduce the pressure of the capillary water surface in the soil to less than one atmosphere. Under these conditions, a movement of moisture must take place from the capillary spaces of the soil to the capillary spaces in the porcelain tube where a greater capillary pressure exists. Now the curvature of the capillary water surface on the outside of the porcelain tube must always be sufficient to withstand the pressure of one atmosphere produced by the exhaustion of the tube, hence the water drawn into these spaces must be forced through the tube by the difference in pressure between the outside and inside of the tube, in order that the necessary curvature of the outer capillary surface may be maintained. A steady movement of water into the tube will, therefore, take place. This rate obviously depends: (1) Upon the difference in curvature of the capillary surfaces on the outside of the tube and in the soil mass, *i. e.*, upon the moisture gradient; (2) upon the resistance encountered by the water in moving over the surfaces of the grains and through the capillary spaces.

The apparatus, with which the results given below were obtained, consists of a Pasteur-Chamberland filter tube, connected by means of a short piece of lead tubing to an exhausted two-liter bottle. Air-tight connections are readily made by the use of short lengths of red rubber tubing, well coated with thick cotton-seed oil. Preparatory to placing the filter tube in the soil, a core of soil is removed by means of a tube, the external diameter of which is equal to that of the smaller end of the porcelain tube. The filter tube is slightly conical in form, so that when it is forced into this hole, a good capillary connection is established between the walls of the tube and the soil.

The apparatus was usually allowed to stand for about twenty-four hours, when the exhausted bottle was detached, and the water which had been drawn into the apparatus removed and measured. The porcelain tube was not disturbed in removing the water, which was drawn into a small flask by suction through a fine tube extending to the bottom of the porcelain tube. The apparatus was then immediately put together again and exhausted by means of an aspirator.

The water thus removed not only represents the amount of water which the soil has supplied to the tube during the preceding period of twenty-four hours, but it appears to be identical in concentration* and composition with the soil solution from which the plant obtains its food.† Therefore, the determination of the amount and composition of its soluble material gives us at once the concentration and composition of the soil solution. The apparatus thus provides a simple means of studying the changes which take place in the solution from which plants obtain their mineral food.

In the following table, the second column gives the rate in grams per hour at which moisture was supplied by the soil to the filter tube; the third, the electrical conductivity at 20° C. of the solution thus obtained, measured always in the same cell. These meas-

* No measurable change is produced in the concentration of a soil solution by filtering it through a porcelain filter-tube which is free from organic matter, and which has been thoroughly washed. A tube clogged with chlorophyll, on the other hand, does actually appear to filter out a part of the solvent from some solutions, the unfiltered portion immediately about the filter-tube being more concentrated than the original solution. See Bull. No. 19, Bureau of Soils, U. S. Dept. of Agri., 1901.

† The arguments in support of this statement will be given in a subsequent paper.

urements consequently serve to indicate the variation in the concentration of the soil solution. The fourth column gives the moisture content of the surrounding soil taken at a distance of from twelve to fifteen inches from the tube. These determinations are rather unsatisfactory, since it was not possible to obtain the samples at a uniform distance from the tube, and the moisture determinations are, therefore, not strictly comparable.

Soil Moisture Removed by Artificial Root.

Date.	Rate in Grams per Hour.	Electrical Conductivity at 20° C.	Moisture Content Per Cent.	Remarks.
June 7–8	8.9			Heavy rain.
8–9	6.5		19.2	
9–10	6.1	75.8		Heavy rain.
10–11	7.2	76.8		
11–13	5.3	78.8	18.5	
13–14	3.9	80 0	18.7	
14–15	2.8	81.6	18.1	
15–16	2.7	82.4	17.3	
16–17	2.2	84.3	18.4	
17–18	2.2	89.2	19.1	
18–20	1.8	86.5	18.1	
20–21	1.7	86.5	17.3	
21–22	2.0	89.7	20.5	Rain.
22–23	1.6	89.8	18.3	
23–24	1.1	87.9	17.5	
24–25	0.9	88.8	16.9	
June 30–July 1	13.7	89.0	22.4	Heavy rains.
1–2	9.5	83.0	21.9	
2–5	4.0	86.4	17.8	
5–6	2.2	87.9	17.7	
6–7	1.5	88.8	17.9	
7–8	8.3	82.0	23.2	Heavy rains.
8–9	9.3	80.8	22 3	
9–11	12.4	84.0	22.2	Showers.
11–12	5.8	86.9	21.9	Showers.
12–13	8.1		21.7	
13–14	6.2	86.4	20.2	
14–15	4.2	88.4	18.7	
15–16	3.2	90.4	17.8	
16–18	3.5	91.2	19.3	Rain.
18–19	2.7	91.1	18.6	
19–20	2.0	92.5	17.9	

The soil in which these experiments were made had been heavily fertilized the previous year. It will be noted that the conductivity, which we may assume as approximately proportional to the salt content, steadily increased from the beginning of the observations, June 7 until June 18. The rain on June 21 apparently did not change the concentration of the solution. After the rain on July 1, the conductivity dropped from 89 to 83, after which it steadily increased until the next rain on July 7. From that time, the conductivity increased from 81 to 91 on July 16. The rain on the latter date did not change the conductivity, due, perhaps, to an accumulation of soluble material at the surface as the result of evaporation on the preceding days, which was carried down by the rain. The maximum increase in the electrical conductivity of the soil solution, taking the initial value as a basis of comparison, amounted to about 21 per cent. The increase in the total solids, determined gravimetrically by evaporating a given volume of the soil solution to dryness, was about 32 per cent., the total solids varying from 1.6 gms. to 2.1 gms. per liter of solution. The maxima in the curves, representing the variation in the electrical conductivity and total solids in the soil solution, do not always correspond, which indicates a change in the composition of the solution as well as in the concentration.

The rate of translocation of the soil moisture into the tube, at the beginning of the experiment, after a heavy rain, was 8.9 grams per hour. It fell steadily during the next two weeks to about 1 gram per hour. Heavy rains in July 1 brought the rate up to an average of 13.7 grams per hour for the twenty-four hour period, after which it fell to 1.5 grams per hour on July 7, and so on.

The rates given represent, of course, the average rate for the period. At the time of a shower, the rate would temporarily be much greater. The apparatus is amply able to remove the water as fast as it can be supplied. A tube in good condition, when immersed in water and exhausted, will take up water at the rate of 50 grams per minute, while the greatest rate recorded in the table is only about one two-hundred-and-fiftieth as fast.

The apparatus thus provides:

(1) A means of determining the rate at which water can be supplied by a soil to an artificial root, by means of which a capillary pull is exerted upon the soil moisture of any desired magnitude up to one kilogram per sq. cm. This makes possible the comparison of rates of capillary movement in different soils under field conditions.

(2) A simple method of removing a portion of soil moisture with the dissolved substances which it contains, thereby enabling a study of the concentration and composition of the soil solution under different field conditions.

This apparatus has the disadvantage of being able to remove water from the soil only when

the latter is comparatively moist; in other words, it fails to give us information regarding the rate of movement of soil moisture during conditions approximating a drouth. Experiments are now in progress with a view to extending the range of the apparatus.

L. J. BRIGGS.
A. G. MCCALL.
PHYSICAL LABORATORY,
BUREAU OF SOILS, U. S. DEPT. OF
AGRICULTURE, October 12, 1904.

NOTES ON INORGANIC CHEMISTRY.

THE first fall number of the *Berichte* of the deutschen chemischen Gesellschaft, with its more than six hundred pages, brings an unusually large number of papers on inorganic chemistry. Several of these are of general interest.

IRON HYDROXID AS AN ANTIDOTE FOR ARSENIC.

THE discovery that freshly precipitated ferric hydroxid is an antidote for arsenic was made by Bunsen in 1834, and was the subject of his earliest scientific publication. He attributed the antidotal effect to the formation of a basic ferric arsenite; indeed, by working in an acetic acid solution he obtained a precipitate of such constitution. The suggestion was, however, early made that it was possible that a finely divided powder, of no physiological or chemical action, could under certain circumstances be active as an antidote in cases of poisoning, and large doses of magnesia were found by some physicians to be as efficient as the ferric hydroxid. The whole subject has now been gone over by Dr. Wilhelm Biltz, who finds as a matter of fact that no compound is formed between the arsenic and iron, but that the gelatinous precipitate acts wholly by adsorption. When the iron oxid is present in the proportion of eight parts to one of arsenious oxid, the removal of the arsenic from solution is almost complete. Dr. Biltz offers the suggestion that the action of antitoxins may be susceptible of a similar explanation.

PHOSPHORESCENT ZINC SULFID.

SOME ten years ago a description was published by Henry of the preparation of a brilliantly phosphorescing zinc blende which is known as 'Sidot Blende.' In this preparation one of the essentials was that the zinc used should be chemically pure. In this *Berichte* the subject is taken up by two observers, who independently come to the same conclusion, which is that a good preparation can not be made unless traces of impurity are present. The amount of this impurity should be very small, Grüne obtaining the best results when his blende contained one ten thousandth part of copper. This blende has a beautiful green phosphorescence. Silver, lead, bismuth, tin, uranium or cadmium can be substituted for the copper with good results. Hofmann finds that the best blende can be prepared by adding common salt and magnesium chlorid to a solution of the purest ammonium zinc sulfate, and precipitating with hydrogen sulfid. The unwashed precipitate is then heated to a white heat for half an hour. The resultant blende is composed of fine crystals and phosphoresces after exposure to the sunlight even more intensely than the best 'luminous paint.' Both observers find that when manganese is present as the impurity in the blende, the mass gives an especially beautiful golden yellow phosphorescence, which is also induced by friction, as is the case with some natural blendes. These artificial blendes are particularly valuable for use with radium, but they have no radio-activity of their own.

PLATINUM SULFATE.

SOME time since it was announced by Margules that platinum could be brought into solution in sulfuric acid by the action of the alternating current between platinum poles. At that time the compound formed could not be made to crystallize and its constitution was doubtful. More recently, by using concentrated sulfuric acid Margules has obtained the compound in deep orange-red crystals which are very hygroscopic and excessively soluble in water. These have been analyzed by Stuchlik, and found to be the sulfate of quadrivalent platinum of the composition, $Pt(SO_4)_2, 4H_2O$. When the salt has been completely freed from the adherent sul-

furic acid by repeated recrystallization it loses its water of crystallization readily, becoming much darker, but when a trace of sulfuric acid is still present the salt is very stable, hardly changing at 100°.

A NEW CARBID OF MOLYBDENUM.

In his book upon the electric furnace Moissan describes a carbid of molybdenum of the formula Mo_2C. This is formed at the highest temperature of the electric furnace, from a mixture of the oxid of molybdenum and carbon. If an excess of carbon is used, it is found in the mass as graphite. Now by working at a somewhat lower temperature, and having in the furnace the metal molybdenum with a little carbon and an excess of aluminum, a new carbid is formed, of the formula MoC. It is obtained as a gray crystalline powder, harder than quartz but less hard than the ruby. It is not attacked by water even at 600° and hardly by acids except nitric. It is analogous to the carbid of tungsten, WC, and Moissan considers that it is present as a double carbid in molybdenum steel.

J. L. H.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

MINUTES OF SPECIAL MEETING OF COMMITTEE ON POLICY OF THE ASSOCIATION.

The committee met at Philadelphia, on October 21, at 2 P.M., Messrs. R. S. Woodward, H. L. Fairchild, J. McK. Cattell, Edgar F. Smith and L. O. Howard being present. In the absence of the president, Mr. Woodward took the chair.

The matters referred to the committee by the council at the St. Louis meeting were taken up in order with the following actions:

1. In regard to the disposal of back volumes it was

Recommended, That the permanent secretary be authorized to offer sets of the back volumes of the proceedings to libraries which shall be approved by a committee of the association appointed by the president.

2. The amendment to article 34, of the constitution, relating to the abolition of the $2 fee for fellowship was considered and it was

Recommended, That the amendment be adopted.

3. The amendment to article 4 line 2, to read 'The members of at least one year's standing who are professionally engaged in science and have by their labors aided in advancing science,' was considered, and it was unanimously

Recommended, That the amendment be not passed.

4. The subject of a possible amendment to article 17 of the constitution was considered and action was postponed.

5. The question of trimming the edges of the journal Science, which had been referred to the committee was considered and it was

Recommended, That the publishers of Science be requested to announce prominently that cut copies will be sent to members who request it.

The following new matters were then brought up and the following actions taken:

1. The committee on the policy of the association recommends that two or three addresses of the vice-presidents be given on each afternoon of the week of the meeting and that the addresses be followed by a discussion or series of papers that will be of interest to students of other sciences and to the intelligent public. It is recommended that the addresses before Sections A, E and F be given on Wednesday; before Sections B, G and I, on Thursday, and before Sections C, D and H on Friday. The secretaries and sectional committees are requested to prepare suitable programs to follow the addresses of the vice-presidents.

2. The committee on policy of the association requests the permanent secretary to write a letter to each member of the sectional committees calling attention to the fact that the alteration of the constitution making the term of office five years creates a council for each section. It is hoped that each member will if possible be present at the Philadelphia meeting and before, during and after the meeting endeavor to promote the interests of the section and of the sciences included in it. The sectional committees are expected to make the program as strong as possible, inviting mem-

bers or guests to present papers when this seems desirable and to arrange one afternoon meeting the proceedings of which will be of interest to as many members of the association as possible. They should see that all members of their section professionally engaged in science are proposed for election as fellows, and it will be a great service to the association if they will take an active part in increasing the membership of the association, especially among workers in the sciences included in their section. A list of members of sectional committees should be published in the annual volume and each member of the committee should be informed of the fact 60 days before any meeting.

3. The following resolution was adopted:

Resolved, That the permanent secretary and the secretary of the council and the general secretary be requested to nominate as fellows all members of the association who are members of the following national scientific societies which are assumed to have a qualification for membership equal to the qualification for fellowship in the association: American Society of Naturalists, American Philosophical Society, American Academy of Arts and Sciences, American Anthropological Association, Association of American Anatomists, Association of American Physicians, Association of Pathologists and Bacteriologists, Astronomical and Astrophysical Society of America, Botanical Society of America, Geological Society of America, American Mathematical Society, active members of the American Ornithological Union, American Philosophical Association, American Physical Society, American Physiological Society, American Psychological Association, American Society of Bacteriologists, Society of Plant Morphology and Physiology and the American Zoological Society.

4. The following resolution was adopted:

Resolved, That the committee on the policy of the association recommends as members and, if they become members, nominates as fellows, members of the national scientific societies not now members of the association, in cases in which the national scientific society has a qualification for membership equal to that of the qualifications of the association for fellowship. The following societies are accepted as having such qualifications: (Same list as in resolution 3.)

Resolved, That the permanent secretary be requested to communicate this resolution to each member of these societies, not already a member of the association.

5. The following resolution was introduced by Mr. Woodward and after discussion the permanent secretary on his own motion was requested to have it manifolded and sent to all members of the committee on policy of the association, further consideration to be postponed until a meeting of the committee on policy to be held on Tuesday night, December 27, at hotel headquarters in Philadelphia:

Resolved, That the committee on policy recommends that the Association continue to hold its principal meeting in winter during convocation week, that this meeting be held as a rule in one of the larger cities of the country, and that efforts be made to secure as full a representation of affiliated societies and as large an attendance of members as possible. The committee recommends that in addition arrangements be made for a summer meeting, not necessarily of the whole association, but of such sections and affiliated societies as care to meet together. The place of meeting would be selected with a view to the summer season and with reference to the geographical distribution of members who could not conveniently attend the winter meeting. The following places of meeting are suggested with a view to discussion, since it is important that provisional arrangements be made well in advance for the convenience of the affiliated societies.

Winter.		Summer.	
1904-05.	Philadelphia.	1905.	Ithaca.
1905-06.	New Orleans.	1906.	Ann Arbor.
1906-07.	Boston.	1907.	Berkeley.
1907-08.	Washington.	1908.	Woods Hole.
1908-09.	Chicago.	1909.	Montreal.
1909-10.	New York.	1910.	Madison.
1910-11.	San Francisco.	1911.	Bar Harbor.
1911-12.	Baltimore.	1912.	Columbus.

Dr. Smith, for the local committee for the coming Philadelphia meeting, made a report of progress on the arrangements for the meet-

ing, concerning which there was a general discussion.

After discussion of certain other matters concerning which no action was taken the committee adjourned at 4 P.M.

L. O. HOWARD,
Secretary.

WASHINGTON,
October 23, 1904.

SCIENTIFIC NOTES AND NEWS.

A SCIENTIFIC session of the National Academy of Sciences will be held at Columbia University, beginning on Tuesday, November 15, 1904.

DR. CHARLES BASKERVILLE, head of the department of chemistry in the College of the City of New York, has been presented with a loving cup, designed by Tiffany and Company, by his former colleagues and students at the University of North Carolina, on the occasion of the tenth anniversary of his doctorate.

WE learn from the *Journal of the American Medical Association* that Dr. George M. Sternberg, Surgeon-General, U. S. A. (retired), has accepted the position of director of the Wills Mountain Sanatorium, situated near Cumberland, Md. The present efficient house staff will be retained. Dr. Sternberg will spend a considerable portion of his time at the sanatorium, which is a health resort for chronic invalids and convalescents.

THE department of botany, Columbia University, recently held an informal reception in honor of Professor K. Goebel, of the University of Munich, and Professor Hugo de Vries, of the University of Amsterdam, immediately before their departure for their homes.

AT the meeting of the International Association of Academies held in London last May the following special committee was appointed 'to consider as to the best methods of making accurate magnetic observations at sea with a view to carrying out a magnetic survey around a parallel of latitude': Professor von Bezold (chairman), Professor Mascart, Professor Palazzo, Sir Arthur Rücker, Lord Kelvin, Dr. Bauer, Professor Liznar, General Rykathew, Professor Wiechert, Dr. Paulsen.

PROFESSOR PIERANDREA SACCARDO, of the University of Padua, has been elected a corresponding member of the Reale Accademia dei Lincei of Rome.

DR. GEORG GAFFKY, of the University of Giessen, who recently succeeded Dr. Robert Koch as director of the Berlin Institute for Infectious Diseases, has been made an honorary citizen of Giessen in recognition of his services to the public health of the city.

THE French Association for the Advancement of Science will hold its annual meeting at Cherbourg in 1905. The officers elected at the recent meeting at Grenoble are as follows: *President,* M. Giard, professor of the theory of evolution at the University of Paris and member of the Institute of France; *Vice-President,* M. Lippmann, professor of physics at the University of Paris and member of the Institute of France; *Secretary,* M. Gaston Saugrain, of the Court of Appeals, Paris; *Vice-Secretary,* M. Carlo, Bourlet, professor of mathematics at the Lycée St. Louis; *Treasurer,* for four years, M. Emile Galanté.

M. GASTON BONNIER, professor of botany at the University of Paris, has been elected a member of the Royal Microscopical Society of London.

PROFESSOR WM. B. ALWOOD, for sixteen years a member of the faculty of the Virginia Polytechnic Institute, has resigned owing to dissatisfaction with the conditions of scientific work at Blacksburg. He will pursue special investigations at Charlottesville, Va., under direction of the Bureau of Chemistry, U. S. Department of Agriculture.

AT the recent celebration of the seventy-fifth anniversary of McGill University, Principal Peterson delivered an address in which he sketched the history of the university and the progress it had made. The lecture served also to honor the anniversary of the birthday of the late Hon. James McGill, its founder.

ACCORDING to *The Botanical Gazette,* the Imperial Academy of Sciences at Vienna has granted 4,000 Kroner to Professor Julius Wiesner for his journey to the Yellowstone National Park, where he expects to study the light relations of the flora.

THE Royal Society of Sciences at Göttingen has made grants, aggregating 5,600 Marks, to Dr. Brendel to assist in the publication of his edition of the works of Gauss; to Dr. Riecke and Professor Wiechert for the continuation of their researches on atmospheric electricity; to Professor Wiechert for seismological work in the Alps, and to Dr. Wagner for a catalogue of ancient maps.

THE International Surgical Congress, recently in session at Paris, has appointed a committee of specialists to examine the claims of Dr. Doyen that he has discovered a serum curing cancer.

A COMMITTEE has been formed at Copenhagen to collect fund for the erection of a monument to Professor Niels Finsen.

JOHN LIVINGSTON DINWIDDIE BROTHWICK, chief engineer in the United States Navy (retired), died from nervous prostration, at Florence, on October 22, at the age of sixty-four years.

The British Medical Journal states that the legacy of £25,000 left by the late Professor Puschmann, of Vienna, to the University of Leipzig, is to be applied to the study of the history of medicine. It is proposed to found a historical museum of medicine, and a special seminary for training persons in medico-historical research and in historiography, with a salaried director and assistant. The names of Dr. Sudhoff and Dr. von Oefele have already been suggested, both eminent in the science of the history of medicine. Professor Puschmann was professor of the history of medicine at Leipzig until 1879, when he accepted a call to a similar chair at Vienna. He died in 1899, and his will was at first contested, but the money has now been paid to the university.

THE annual meeting of the British Iron and Steel Institute is being held in New York City this week. About 350 members and guests were expected to be present.

The British Medical Journal states that the foundation of a German Physiological Society is one of the outcomes of the meeting of German Men of Science and Physicians recently held at Breslau. Professor Schenk, of Marburg is president and Professor Hürthle, of Breslau, treasurer of the new society. The first meeting of the society will be held at Marburg at Whitsuntide, 1905.

WE learn from the *Bulletin of the American Mathematical Society* that an effort is being made to establish a society for the study of the history of the natural and technical sciences. The subject was presented at the Third International Congress of Mathematics at Heidelberg last August, and at the International Congress of Philosophy at Geneva in September and attracted favorable attention. Those who are interested in the founding of such a society are asked to communicate at an early date with Ingenieur F. M. Feldhaus, Rohrbach, Heidelberg, Germany.

THE University of Washington proposes to establish a permanent marine station at a point, yet to be decided on, at Puget Sound. During the present summer a temporary station was established at Friday Harbor, in charge of Professor Trevor Kincaid and Dr. T. C. Frye.

DR. ALEXANDER F. CHAMBERLAIN, of Clark University, Worcester, Mass., and William Wallace Tooker, of Sag Harbor, Long Island, are engaged upon a work to be entitled, 'The Proverbs of Solomon, King of Israel. From Eliot's Indian Bible. With Introduction, Notes and Vocabulary.' This is the first attempt to make accessible to scholars and to the public in general any considerable portion of this famous book. The tercentenary of Eliot's birth occurs in 1904 and the 'Book of Proverbs' in this dress will be one of the many tributes to the memory of the 'Indian Apostle.' The difficulties of the work are such that no date of publication can be fixed.

THE London *Times* states that it never uses the same type twice. Every day a new supply is delivered at its offices by the Wicks Rotary Type-Casting Company, amounting on the average to as many as a million letters; and the whole of it is removed on the following day to be put into the melting-pot. Such lavishness could only be possible with type made at extraordinary speed and with exceptional cheapness, and the invention that first

realized these aims was the work of Mr. Wicks, who, curiously enough, is not an engineer by profession, but a journalist, and was formerly a member of the gallery staff of *The Times*. His original invention has been vastly improved in the course of years, and the members of the Civil and Mechanical Engineers' Society, who, headed by the honorable secretary, Mr. A. S. E. Ackermann, paid a visit on August 4 to the works at Willesden where the type-casting wheels are made, spent a couple of very interesting hours among machines and contrivances which strike laymen as little short of magical, but can only be properly appreciated by engineers. Under the guidance of the firm's engineer, Mr. E. G. Tottle, they inspected every process of the manufacture of the punches, the matrices, and the type-casting wheel itself; and, though the actual casting is done at the works in Blackfriars, arrangements had been made by which the operation of one of the finished wheels could be exhibited. Before the invention and perfection of this wheel a type-making machine which could turn out 6,000 types an hour was considered rapid; the Wicks rotary wheel casts 60,000 with ease, and 40 per cent. more cheaply than the old machines. The firm's engineer explained that, after buying the best and most expensive machine in the market, they invariably set to work to alter it until it reached their own standard accuracy. All the calculations (and they are peculiarly complicated, since, to comply with the traditions of printing, the unit is 1-72 part of an inch) are carried out to six places of decimals, and the men who grind the punches or make the wheels work to 1-10,000 part of an inch. The care taken and the quality of the machinery employed may be gauged by the fact that the little punch-cutting machines, which each cost nearly £1,000, are bedded, to avoid vibration, on a depth of 16 feet of concrete, which in its turn is laid on oak piles 5 feet long.

According to foreign papers several parts of Paris are so infested with mosquitoes that the matter of their suppression has been considered by the Conseil d'Hygiène et de Salubrité de la Seine, which recently adopted certain conclusions of which the following is a summary: In the first place stagnant water where their eggs are hatched and localities where the insects collect, such as cellars, sewers and dark places, ought to be kept under observation. Drains and sewers of all kinds, and the openings of the pipes which supply water in the streets, should be regularly inspected to avoid collections of stagnant water, and insects assembling in numbers should be destroyed either by a burning torch or by lime-washing. Roofs and rain-water gutters ought to be examined, and water ought not to be allowed to lodge in the gutters. Nothing capable of holding water should be placed in front of windows, and places which are the haunts of mosquitoes should be well ventilated. Stagnant water should not be allowed to remain in gardens and courtyards. Fountains and basins in public places should be emptied and cleansed at least once a week, and plenty of fish should be kept in large sheets of water. In basins and casks standing on private ground there should be a layer of petroleum oil on the surface of the water (about a gram per square meter), or if the water contains fish a layer of salad oil. The public should be advised to use mosquito curtains. Mosquito bites should be treated with a drop of tincture of iodine or with a drop of a solution of guaiacol of one per cent. strength.

Reports received by the United States Geological Survey for 1903 show that many springs that were formerly used as sources of table waters were commercially abandoned during the previous year. The reports also show a decided loss in the number of gallons of water sold and also in the value of the product—losses ascribed mainly to the fact that many important springs failed to report for the year 1903, although they sent in returns for the previous year. These losses occur in all sections except one. The list of mineral springs reported for 1903 is slightly increased over that of 1902, including now 725 springs instead of 721 as in 1902. The list has been lengthened by the addition of 42 new names. The number of springs dropped from the list, because commercially abandoned, is 38. The springs actually reporting sales for 1903 number 522, which is

127 less than the number reporting in 1902. The springs not heard from number 167, and these, with few exceptions, reported sales in 1902. In addition there are 36 springs which report that no sales were made in 1903, thus increasing the number of delinquents to 203. The average price for a gallon of mineral water is about 16 cents for 1903, as compared with 13.7 cents for 1902. The total production for 1903, including the figures estimated for the delinquent springs, is 50,575,746 gallons, at a valuation of $8,074,096. This is a loss in quantity of 14,283,715 gallons and in value of product of $719,655, as compared with the production of 1902. When the 522 springs actually reporting are alone considered, the figures are 37,707,647 gallons, as compared with 63,174,522 gallons in 1902, a loss of 25,466,905 gallons; and a valuation for 1903 of $6,382,726, compared with $8,634,179 in 1902, a loss of $2,251,453. It is probable that a loss would be shown even had all the springs now delinquent sent in returns. The survey report from which these figures are taken is an extract from the forthcoming volume 'Mineral Resources of the United States, 1903,' and may be obtained, free of charge, from the Director of the United States Geological Survey, Washington, D. C.

THE new number of the quarterly *Bulletin* of the Imperial Institute contains, according to the London *Times*, a number of valuable reports by the scientific and technical department on recent investigations of various British products, undertaken with a view to ascertain their present or potential applicability to commercial needs. An examination of sisal, banana and pineapple fibers from southern Rhodesia, and their submission to commercial experts, has led to the conclusion that they would sell freely in the London market, at remunerative prices, if imported regularly in bulk. Another report shows that Bermuda is capable of becoming a competitor with the foreign countries, chiefly Syria and Caucasian Russia, on which we now depend almost exclusively for our imports of liquorice root. The Bermuda product would occupy an intermediate position between the coarse Syrian and the fine Caucasian root. Leathers from Pemba tanned with local mangrove barks have been found to be suitable for the manufacture of cheap boots, and it is suggested that a remunerative expert trade might be initiated at Zanzibar, in competition with the lower grades of American and Australian leather in demand in this country. Cacao, cotton and honey samples from Trinidad have been favorably reported on, the cacao being quite equal to the highest qualities in the English market. Though found to be incompletely soluble in 70 per cent. alcohol, lemon-grass oil from Montserrat would, it is stated by dealers in essential oils, find a ready sale here and on the continent. There would also be a continental demand, though probably not a home demand, for seeds of the 'physic-nut' tree (*Jatropha Curcas*) of Lagos, as the oil extracted could be employed for soap making. Five of the reports relate to the rubber production of the Empire. One of them gives the results of analyses of rubbers and rubber vines received from Takaunga, the Kamasia Hills and Rabal, in the East Africa Protectorate, while another deals with the *Urceola esculenta* of Burma. The conclusion in respect to the plant is that it will yield marketable rubber of good quality, and the shipment of a trial consignment to this country is recommended. A sample of 'pontianac' obtained from the state forests of Patiala was found to correspond closely with the 'pontianac' extensively used in the United States, and to be equally suitable for utilization in this country in the manufacture of low-grade rubber goods. In addition to the reports referred to, various general notices are given respecting economic products and their development, together with a detailed description of the eucalyptus oils of New South Wales, as illustrated by an extensive exhibit now open to the public and presented to the institute by the Technological Museum of Sydney.

UNIVERSITY AND EDUCATIONAL NEWS.

THE will of Mr. James Callanan, of Des Moines, makes bequests for educational institutions as follows: Talladega College, Alabama, $100,000; Casenovia College, New York, $5,000; Penn College, Oskaloosa, Iowa, $10,-

000; Des Moines College, \$5,000; Wilberforce University, Green, O., \$5,000; Ambidexter Institute, Springfield, Ill., \$10,000.

The *Educational Times* states that of the £170,000 required for the endowment of Sheffield University nearly £110,000 has been collected or promised. The Duke of Norfolk, who is named as the chancellor of the new university, has given £10,000. All classes of the community have contributed freely. The claims of the scheme are being advocated in the large towns near Sheffield, such as Rotherham, Doncaster, Barnsley and Chesterfield, on the support of which the stability of the university largely depends. It is essential to the success of the scheme that the public grants should be largely increased. The Sheffield city council now supports the technical department of the college to the extent of about £5,000 a year, but has promised, if the charter is granted, to make a yearly contribution to the arts, science and medical departments of a sum not exceeding the revenue of a penny rate, which is expected to produce some £6,700 a year, or about £5,000 more than the council now pays to those departments. The West Riding county council has set aside £6,000 a year for the universities in Yorkshire. This sum has not yet been divided between Leeds and Sheffield. In addition, it is anticipated that the Derbyshire county council, as well as some of the surrounding local authorities, will contribute.

At a recent meeting of the Harvard faculty, it was voted to change the requirements for the degree of A.M. and to allow undergraduates who have completed the requirements for the degree of A.B., with the exception of a single course, to be admitted to the graduate school as candidates for A.M.

The following appointments and promotions have been made at the College of Physicians and Surgeons, Columbia University: Dr. Gorham Bacon, professor of otology; Dr. Joseph A. Blake, professor of surgery; Dr. George E. Brewer, professor of clinical surgery; Dr. Frederick R. Bailey, adjunct professor of normal histology; Dr. Arnold Knapp, professor of ophthalmology; Dr. Eugene Hydenpyl, adjunct professor of pathological anatomy; Dr. Frederick Peterson, clinical professor of psychiatry; Dr. Francis Carter Wood, adjunct professor of clinical pathology, and Dr. Russell Burton-Opitz, adjunct professor of physiology.

Mr. James Walter Goldthwait, of Lynn, Mass., has been appointed instructor in geology at Northwestern University. Mr. Goldthwait took his undergraduate and his graduate work at Harvard University, where he was also one of the corps of instruction.

The following appointments have been made to the teaching force of the Michigan College of Mines, Houghton, Michigan: Arthur Alexander Koch, Ph.D., University of Basel, instructor in chemistry; Charles Franklin Bowen, M.S., University of Wisconsin, and Eugene Thomas Hancock, B.S., University of Wisconsin, instructor in geology and mineralogy; Charles Hamilton Hoyt, C.E., Thayer College of Engineering, instructor in civil and mining engineering; Durward Copeland, B.S., Massachusetts Institute of Technology, instructor in metallurgy and ore dressing.

W. L. Powers, Cornell College, '03, has been appointed assistant in inorganic chemistry in the Medical College of Sioux City.

Dr. William Palmer Wynne, D.Sc. (Lond.), F.R.S., senior honorary secretary of the Chemical Society and professor of chemistry in the School of Pharmacy of the pharmaceutical Society, has been appointed to the Firth chair of chemistry in University College, Sheffield, in succession to Professor Carleton Williams.

Dr. Albert S. Grünbaum, lecturer in experimental medicine in Liverpool University and director of the Liverpool Cancer Research, has been appointed professor of pathology and bacteriology.

Mr. J. J. Lister, M.A., fellow of St. John's, Cambridge University, has been appointed demonstrator of comparative anatomy until Michaelmas, 1905.

At the University of Brussels, Drs. G. Dwelshawers and R. Berthelot have been promoted to full professorships of philosophy and Dr. Stroobant to a professorship of astronomy.